DESCRIPTION

PICTURE PROCESSING APPARATUS, PICTURE PROCESSING METHOD,

PROGRAM, AND RECORD MEDIUM

Technical Field

5   The present invention relates to a picture

processing apparatus, a picture processing method, a

program, and a record medium applicable to a noise

eliminating apparatus and a noise eliminating method

for eliminating noise of for example a picture signal

10   and to a picture converting apparatus and a picture

converting method for converting an input picture

signal into a picture signal with a higher resolution

than the input picture signal.

Background Art

15   Picture signal processing apparatuses are

categorized as two types. The first type is an

apparatus having a structure of which a picture signal

is stored as time elapses. The second type is an

apparatus using a class categorizing adaptive process

20   proposed by the applicant of the present invention.

Exemplifying a noise eliminating process, Fig. 1 shows

the structure of which a picture signal is stored as

time elapses. This structure is known as a motion

adaptive type recursive filter.

25   An input picture signal is supplied to an

adding circuit 2 through an amplifier 1 that adjusts

the amplitude of the input picture signal in such a

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manner that one pixel is supplied at a time. An output
picture signal of a frame that immediately precedes the
current frame (namely, the current frame of an input
picture signal (hereinafter referred to as current

5   frame) has been stored in a frame memory 3. (The frame
that immediately precedes the current frame is referred
to as preceding frame.) The picture signal stored in
the frame memory 3 is read successively pixel by pixel
corresponding to pixel positions of the input picture

10   signal and supplied to the adding circuit 2 through an
amplifier 4 that adjusts the amplitude of the picture
signal.

The adding circuit 2 adds a pixel of the
current frame that is output from the amplifier 1 and a

15   pixel of the preceding frame that is output from the
amplifier 4 and outputs the added output as an output
picture signal. In addition, the adding circuit 2
outputs the added output to the frame memory 3. The
frame memory 3 rewrites the picture signal stored

20   therein with the output picture signal of the adding
circuit 2.

In addition, the input picture signal of the
current frame is supplied pixel by pixel to a
subtracting circuit 5. The picture signal of the

25   preceding frame stored in the frame memory 3 is read
pixel by pixel corresponding to the pixel positions of
the input picture signal and supplied to the

subtracting circuit 5. The subtracting circuit 5 outputs the difference between the pixel values of pixels at corresponding positions of pictures of the current frame and the preceding frame.

5   The difference that is output from the subtracting circuit 5 is supplied to an absolute value calculating circuit 6. The absolute value calculating circuit 6 calculates the absolute value of the difference that is output from the subtracting circuit 10   5. The calculated absolute value is supplied to a threshold value processing circuit 7. The threshold value processing circuit 7 compares the absolute value of the supplied difference of the pixel values with a predetermined threshold value and determines whether 15   each pixel is a moving portion or a still portion. When the absolute value of the difference of the pixel values is smaller than the threshold value, the threshold value processing circuit 7 determines that the input pixel is a still portion. In contrast, when 20   the absolute value of the difference of the pixel values is larger than the threshold value, the threshold value processing circuit 7 determines that the input pixel is a moving portion.

    The determined result representing whether 25   the input pixel is a still portion or a moving portion is supplied from the threshold value processing circuit 7 to a weighting coefficient generating circuit 8. The

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weighting coefficient generating circuit 8 designates a
value of a weighting coefficient ($0 \leqq k \leqq 1$)
corresponding to the determined result of the threshold
value processing circuit 7 and supplies the designated

5   coefficient k to the amplifier 1. In addition, the
weighting coefficient generating circuit 8 supplies a
coefficient (1 - k) to the amplifier 4. The amplifier
1 multiplies the input signal by k. In contrast, the
amplifier 4 multiplies the input signal by (1 - k).

10   In this case, when the determined result of
the threshold value processing circuit 7 represents
that the pixel of the current frame is a still pixel, a
constant value in the range of k = 0 to 0.5 is
designated as the value of the coefficient k. Thus,

15   the output of the adding circuit 2 is a value of which
the pixel values of the current frame and the preceding
frame that have been weighted and added.

On the other hand, when the determined value
of the threshold value processing circuit 7 represents

20   that the pixel of the current frame is a moving portion,
k = 1 is designated as the value of the coefficient k.
Thus, the adding circuit 2 outputs the pixel value of
the current frame (namely, the pixel value of the input
picture signal).

25   The stored signal of the frame memory 3 is
rewritten frame by frame with the output picture signal
of the adding circuit 2. Thus, a still portion of the

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picture signal stored in the frame memory 3 is a

cumulated value of pixel values of a plurality of

frames. Thus, assuming that noise varies in each frame

at random, when weighted additions are performed, the

5   noise gradually becomes small and is finally eliminated.

Thus, noise is eliminated from a still portion of a

picture signal stored in the frame memory 3 (the still

portion is the same as an output picture signal).

However, when noise is eliminated using the

10   motion adaptive type recursive filter, the following

problems arise.

When a noise level is large, a moving portion

may be mistakenly detected as a still portion. In this

case, the picture quality may deteriorate (for example,

15   the picture may become unsharp). In addition, noise

cannot be eliminated from a moving portion.

On the other hand, a noise eliminating

apparatus using the class categorizing adaptive process

has been proposed by the applicant of the present

20   invention. In the class categorizing adaptive process,

noise can be eliminated regardless of whether a pixel

of a still portion or a moving portion. However, the

motion adaptive type recursive filter has a higher

noise eliminating performance than the noise

25   eliminating apparatus using the class categorizing

adaptive process.

Besides the noise eliminating process, the

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present invention can be effectively applied for a resolution converting apparatus that increases the resolution of an input picture signal.

In other words, at present, there are a variety of television systems that are for example so-called standard systems of which the number of scanning lines per frame is 525 or 625 and high resolution systems of which the number of scanning lines per frame is larger than that of the standard systems (for example, high vision system using 1125 scanning lines).

In this case, to allow an apparatus corresponding to for example a high resolution system to handle a picture signal corresponding to the standard system, it is necessary to convert a picture signal with a resolution corresponding to the standard system into a picture signal with a resolution corresponding to the high resolution system (this process is sometimes referred to as upconvert). To solve such a problem, various types of resolution converting apparatuses using linear interpolating method and so forth have been proposed. For example, upconvert using storage type process and upconvert using class categorizing adaptive process have been proposed.

In a resolution converting apparatus using storage type process that outputs a converted output picture, although a still picture portion less

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deteriorates, a large moving portion deteriorates. On

the other hand, in a resolution converting apparatus

using class categorizing adaptive process that outputs

a converted output picture, although a moving picture

5   portion less deteriorates, a still picture portion

deteriorates.

        In other words, so far, it was difficult to

accomplish a resolution converting apparatus that can

form a picture that less deteriorates for both a still

10   picture portion and a moving picture portion.

        Thus, an object of the present invention is

to provide a picture processing apparatus, a picture

processing method, a program, and a record medium that

allow an advantage of a structure of which a picture

15   signal is stored as time elapses and an advantage of a

structure of which a class categorizing adaptive

process is used to be effectively used so as to perform

a good process as a whole.

Disclosure of the Invention

20   Claim 1 of the present invention is a picture

processing apparatus for receiving an input picture

signal and generating an output picture signal with

higher quality than the input picture signal,

comprising:

25   a first signal processing means, having

storing means for storing a picture signal with the

same quality as the output picture signal, the first

signal processing means adding the input picture signal
and the picture signal stored in the storing means so
as to generate a first picture signal with higher
quality than the input picture and store the first

5   picture signal to the storing means;

a second signal processing means for
extracting a feature of the input picture signal
corresponding to the position of a considered pixel of
the output picture signal, categorizing the considered

10   pixel as one of a plurality of classes corresponding to
the feature, and calculating the input picture signal
using a predetermined calculating method corresponding
to the categorized class so as to generate a second
picture signal with higher quality than the input

15   picture signal; and

an output selecting means for performing a
determination for the first picture signal and the
second picture signal and selecting one of the first
picture signal and the second picture signal as the

20   output picture signal.

Claim 26 of the present invention is a
picture processing method for receiving an input
picture signal and generating an output picture signal
with higher quality than the input picture signal,

25   comprising the steps of:

storing a picture signal with the same
quality as the output picture signal to storing means,

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adding the input picture signal and the picture signal
stored in the storing means so as to generate a first
picture signal with higher quality than the input
picture and store the first picture signal to the

5   storing means;

extracting a feature of the input picture
signal corresponding to the position of a considered
pixel of the output picture signal, categorizing the
considered pixel as one of a plurality of classes

10   corresponding to the feature, and calculating the input
picture signal using a predetermined calculating method
corresponding to the categorized class so as to
generate a second picture signal with higher quality
than the input picture signal; and

15   performing a determination for the first
picture signal and the second picture signal and
selecting one of the first picture signal and the
second picture signal as the output picture signal.

Claim 51 of the present invention is a

20   program for causing a computer to execute a picture
process for generating an output picture signal with
higher quality than an input picture signal, the
picture process comprising the steps of:

storing a picture signal with the same

25   quality as the output picture signal to storing means,
adding the input picture signal and the picture signal
stored in the storing means so as to generate a first

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picture signal with higher quality than the input picture and store the first picture signal to the storing means;

5   extracting a feature of the input picture signal corresponding to the position of a considered pixel of the output picture signal, categorizing the considered pixel as one of a plurality of classes corresponding to the feature, and calculating the input picture signal using a predetermined calculating method

10   corresponding to the categorized class so as to generate a second picture signal with higher quality than the input picture signal; and

performing a determination for the first picture signal and the second picture signal and

15   selecting one of the first picture signal and the second picture signal as the output picture signal.

Claim 52 of the present invention is a computer readable record medium on which a program has been recorded, the program causing the computer to

20   execute a picture process for generating an output picture signal with higher quality than an input picture signal, the picture process comprising the steps of:

storing a picture signal with the same

25   quality as the output picture signal to storing means, adding the input picture signal and the picture signal stored in the storing means so as to generate a first

picture signal with higher quality than the input picture and store the first picture signal to the storing means;

extracting a feature of the input picture signal corresponding to the position of a considered pixel of the output picture signal, categorizing the considered pixel as one of a plurality of classes corresponding to the feature, and calculating the input picture signal using a predetermined calculating method corresponding to the categorized class so as to generate a second picture signal with higher quality than the input picture signal; and

performing a determination for the first picture signal and the second picture signal and selecting one of the first picture signal and the second picture signal as the output picture signal.

Brief Description of Drawings

Fig. 1 is a block diagram showing an example of a conventional motion adaptive type recursive filter.

Fig. 2 is a block diagram showing the basic structure of the present invention.

Fig. 3 is a block diagram showing an embodiment of the present invention.

Fig. 4 is a block diagram showing an example of a noise eliminating circuit using a storage type process according to the embodiment of the present invention.

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Fig. 5 is a flow chart showing a process of the example of the noise eliminating circuit using the storage type process according to the embodiment of the present invention.

5   Fig. 6 is a block diagram showing an example of a class categorizing adaptive noise eliminating circuit according to the embodiment.

Fig. 7 is a schematic diagram showing examples of class taps and predictive taps.

10   Fig. 8 is a block diagram showing an example of a feature detecting circuit that composes the class categorizing adaptive noise eliminating circuit.

Fig. 9 is a schematic diagram for explaining an example of the feature extracting circuit.

15   Fig. 10 is a block diagram showing the structure in which a learning is performed to generate coefficient data used in the class categorizing adaptive noise eliminating circuit.

Fig. 11 is a flow chart for explaining a 20   process of which the embodiment of the present invention is processed by software.

Fig. 12 is a flow chart showing a process of a motion adaptive type recursive filter.

Fig. 13 is a flow chart showing a noise 25   eliminating process of the class categorizing adaptive process.

Fig. 14 is a flow chart showing a process in

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which a learning is performed to generate coefficient
data used in the class categorizing adaptive noise
eliminating circuit.

Fig. 15 is a block diagram showing another
embodiment of the present invention.

Fig. 16 is a schematic diagram for explaining
a resolution converting process according to the other
embodiment.

Fig. 17 is a block diagram showing the
structure of an example of a resolution converting
portion using the storage type process according to the
other embodiment.

Fig. 18 is a schematic diagram for explaining
a converting process of the resolution converting
portion using the storage type process.

Fig. 19 is a schematic diagram for explaining
the converting process of the resolution converting
portion using the storage type process.

Fig. 20 is a block diagram showing the
structure of an example of a resolution converting
portion using the class categorizing adaptive process.

Fig. 21 is schematic diagram for explaining a
process and an operation of the resolution converting
portion using the class categorizing adaptive process.

Fig. 22 is a block diagram showing an example
of a feature detecting circuit of the resolution
converting portion using the class categorizing

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adaptive process.

Fig. 23 is a schematic diagram for explaining the operation of the feature detecting circuit.

Fig. 24 is a block diagram showing the

5   structure in which a learning is performed to generate coefficient data used in the resolution converting portion using the class categorizing adaptive process.

Fig. 25 is a schematic diagram for explaining a selecting process for an output picture signal

10   according to the other embodiment.

Fig. 26 is a flow chart for explaining the selecting process for the output picture signal according to the other embodiment.

Fig. 27 is a flow chart for explaining a

15   process of which the other embodiment of the present invention is accomplished by software.

Fig. 28 is a flow chart showing a converting process of the resolution converting portion using the storage type process.

20   Fig. 29 is a flow chart showing the resolution converting process using the class categorizing adaptive process.

Fig. 30 is a flow chart showing a process in which a learning is performed to generate coefficient

25   data used in the resolution converting process using the class categorizing adaptive process.

Best Modes for Carrying out the Invention

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Fig. 2 shows the overall structure of the
present invention. An input picture signal is supplied
to a storage type processing portion 100 and a class
categorizing adaptive processing portion 200. The

5   storage type processing portion 100 is a processing
portion that has the structure for storing a picture
signal as time elapses. In contrast, the class
categorizing adaptive processing portion 200 detects a
feature of an input picture signal corresponding to the

10   position of a considered pixel of an output picture
signal, categorizes the considered pixel as one of a
plurality of classes corresponding to the detected
feature, and calculates the input picture signal using
a predetermined calculating system corresponding to the

15   categorized class so as to generate the output picture
signal.

        An output picture signal of the storage type
processing portion 100 and an output picture signal of
the class categorizing adaptive processing portion 200

20   are supplied to a selecting circuit 301 and an output
determining circuit 302 of an output selecting portion
300. The output determining circuit 302 determines one
of the output picture signals to be output
corresponding to output picture signals of the

25   processing portions. The output determining circuit
302 generates a selection signal corresponding to the
determined result. The selection signal is supplied to

the selecting circuit 301. The selecting circuit 301 selects one of the two output picture signals corresponding to the selection signal.

When the present invention is applied to a noise elimination, the storage type processing portion 100 has the same structure as the above-mentioned motion adaptive type recursive filter. By performing the weighted additions of the current frame and the preceding frame, noise is adequately eliminated from pixels of a still portion.

On the other hand, the class categorizing adaptive processing portion 200 is a noise eliminating portion using the class categorizing adaptive process. The noise eliminating portion using the class categorizing adaptive process extracts pixels at corresponding positions of a plurality of frames, categorizes noise components of pixels as classes corresponding to variation of pixels among the frames, and eliminates the noise components from the input picture signal by predetermined calculating processes corresponding to the categorized classes. Thus, noise is eliminated from an input picture signal regardless of whether it is a moving portion or a still portion. However, when the input picture signal is a perfect still portion, the storage type noise eliminating portion can more effectively eliminate noise therefrom than the noise eliminating portion using the class

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categorizing adaptive process.

The output selecting portion 300 determines whether an input picture signal in the unit of a predetermined number of pixels is a still portion or a moving portion. When the determined result represents that the input picture signal is a still portion, the output selecting portion 300 selects an output picture signal of the noise eliminating portion using the storage type process. When the determined result represents that the input picture signal is a moving portion, the output selecting portion 300 selects an output picture signal of the noise eliminating portion using the class categorizing adaptive process. Thus, an output picture signal of which noise has been eliminated is obtained regardless of whether an input picture signal is a still portion or a moving portion.

When the present invention is applied to a resolution converting apparatus that up-converts a picture signal, the storage type processing portion 100 stores picture information to a frame memory in the chronological direction for a long time so as to form a picture signal with a high resolution. When an input picture is a still picture or a full screen that simply pans or tilts, with such a structure, a converted picture signal that less deteriorates can be obtained.

On the other hand, the class categorizing adaptive processing portion 200 is a resolution

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converting portion using the class categorizing

adaptive process. The resolution converting portion

categorizes a feature of a considered pixel of a

picture of an input picture signal as a class

5   corresponding to features of a plurality of pixels

including the considered pixel and pixels

chronologically and spatially adjacent thereto and

generates a plurality of pixels of a picture with a

high resolution corresponding to the considered pixel

10   by a predetermined picture conversion calculating

process pre-designated corresponding to the categorized

class so as to generate an output picture signal with a

high resolution. Thus, when an input picture signal is

a moving portion, the resolution converting portion

15   using the class categorizing adaptive process can

obtain a converted output picture signal that less

deteriorates. However, when an input picture signal is

a still portion, the storage type resolution converting

portion that handles a picture signal in the

20   chronological direction for a long time can more

adequately convert the resolution than the resolution

converting portion using the class categorizing

adaptive process.

In consideration of characteristics of those

25   resolution converting portions, the output selecting

portion 300 can select a picture signal that is output

from one resolution converting portion or a picture

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signal that is output from the other resolution converting portion and outputs the selected picture signal. Thus, a converted output picture with high picture quality that less deteriorates can be obtained.

5   Next, with reference to Fig. 3, a noise eliminating apparatus according to the embodiment of the present invention will be described. An input picture signal is supplied pixel by pixel to a motion adaptive type recursive filter 11 that composes an

10   example of the storage type processing portion 100. In addition, the input picture signal is supplied to a class categorizing adaptive noise eliminating circuit 12 that composes an example of the class categorizing adaptive processing portion 200.

15   As the motion adaptive type recursive filter 11, the same structure as the example shown in Fig. 1 can be used. An output picture signal of the motion adaptive type recursive filter 11 is supplied to an output selecting portion 13 corresponding to the output

20   selecting portion 300.

The class categorizing adaptive noise eliminating circuit 12 extracts pixels at corresponding positions of a plurality of frames, categorizes noise components of the pixels as classes corresponding to

25   the variation of the pixels of the frames, and performs predetermined calculating processes corresponding to the categorized classes so as to generate an output

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picture signal of which noise components have been
eliminated from the input picture signal. The detailed
structure of the class categorizing adaptive noise
eliminating circuit 12 will be described later. An

5   output picture signal of the class categorizing
adaptive noise eliminating circuit 12 is also supplied
to the output selecting portion 13.

The output selecting portion 13 has a still
portion - moving portion determining circuit 14, a

10   timing adjustment delaying circuit 15, and a selecting
circuit 16. An output picture signal of the motion
adaptive type recursive filter 11 is supplied to the
selecting circuit 16 through the delaying circuit 15.
An output picture signal of the class categorizing

15   adaptive noise eliminating circuit 12 is directly
supplied to the selecting circuit 16.

The output picture signal of the motion
adaptive type recursive filter 11 and the output
picture signal of the class categorizing adaptive noise

20   eliminating circuit 12 are supplied to the still
portion - moving portion determining circuit 14. The
still portion - moving portion determining circuit 14
determines whether the input picture signal is a still
portion or a moving portion pixel by pixel

25   corresponding to the two output picture signals of the
motion adaptive type recursive filter 11 and the class
categorizing adaptive noise eliminating circuit 12.

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The determined output of the still portion - moving portion determining circuit 14 is supplied as a selection control signal to the selecting circuit 16.

As was described above, as for an output picture signal of the motion adaptive type recursive filter 11, noise is eliminated from a pixel of a still portion of a picture, whereas noise is not limited from a pixel of a moving portion of a picture. On other hand, as for an output picture signal of the class categorizing adaptive noise eliminating circuit 12, noise is eliminated regardless of whether a pixel of a picture is a still portion or a moving portion.

Thus, when the output picture signal of the motion adaptive type recursive filter 11 and the output picture signal of the class categorizing adaptive noise eliminating circuit 12 are compared, since noise is eliminated from still portions of those output picture signals, the pixel values thereof are almost the same. However, although noise remains in a moving portion of the output picture signal of the motion adaptive type recursive filter 11, noise is eliminated from a moving portion of the output picture signal of the class categorizing adaptive noise eliminating circuit 12. Thus, the pixel values of the moving portions of the output picture signals of the motion adaptive type recursive filter 11 and the class categorizing adaptive noise eliminating circuit 12 differ by the noise.

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Using such characteristics, the still portion - moving portion determining circuit 14 determines whether each pixel of an input picture signal is a still portion or a moving portion. In other words, the

5 still portion - moving portion determining circuit 14 has a difference value calculating circuit 141, an absolute value calculating circuit 142, and a comparing and determining circuit 143. The difference value calculating circuit 141 calculates the difference

10 between a pixel value of the output picture signal of the motion adaptive type recursive filter 11 and a pixel value of the output picture signal of the class categorizing adaptive noise eliminating circuit 12. The absolute value calculating circuit 142 calculates

15 the absolute value of the difference value that is output from the difference value calculating circuit 141.

When the absolute value of the difference value that is output from the absolute value

20 calculating circuit 142 is larger than a predetermined value, the comparing and determining circuit 143 determines that the pixel is a moving portion. In contrast, when the absolute value of the difference value that is output from the absolute value

25 calculating circuit 142 is smaller than the predetermined value, the comparing and determining circuit 143 determines that the pixel is a still

portion. When the pixel is a still portion, the comparing and determining circuit 143 causes the selecting circuit 16 to select the output picture signal of the motion adaptive type recursive filter 11.

5   In contrast, when the pixel is a moving portion, the comparing and determining circuit 143 causes the selecting circuit 16 to select the output picture signal of the class categorizing adaptive noise eliminating circuit 12.

10   Thus, when the pixel is a still portion, the selecting circuit 16 (namely, the output selecting portion 13) outputs the output picture signal of the motion adaptive type recursive filter that can store information of a long frame and adequately eliminates

15   noise. In contrast, when the pixel is a moving portion, the selecting circuit 16 outputs the output picture signal of the class categorizing adaptive noise eliminating circuit 12 instead of the output picture signal of the adaptive type recursive filter. Thus, an

20   output picture signal from which noise has been eliminated regardless of whether the pixel is a still portion or a moving portion can be obtained from the output selecting portion 13.

The structure of the motion adaptive type

25   recursive filter 11 is not limited to an example shown in Fig. 1. In other word, the structure of the motion adaptive type recursive filter 11 may be as shown in

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Fig. 4. In Fig. 4, reference numeral 101 represents a
time adjustment delaying circuit. Reference numeral
104 represents a moving vector detecting circuit. An
input picture is supplied to a combining circuit 102

5   through the delaying circuit 101. A picture stored in
a storing memory 103 is supplied to the combining
circuit 102 through a shifting circuit 105. An
combined output of the combining circuit 102 is stored
in the storing memory 103. A picture stored in the

10   storing memory 103 is extracted as an output and
supplied to the vector detecting circuit 104.

The moving vector detecting circuit 104
detects a moving vector of the input picture signal and
the picture stored in the storing memory 103. The

15   shifting circuit 105 shifts the position of the picture
that is read from the storing memory 103 in the
horizontal direction and/or the vertical direction
corresponding to the moving vector detected by the
moving vector detecting circuit 104. The shifting

20   circuit 105 compensates the motion of the picture.
Thus, the combining circuit 102 adds pixels at
spatially corresponding positions of the pictures as
will be described later.

Combined value of output of combining circuit

25   102 = (pixel value of input picture $\times$ N + pixel value
of stored picture $\times$ M) / (N + M) (where N and M are
predetermined coefficients).

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Thus, pixel data of a plurality of frames is cumulatively stored in the storing memory 103. As a result, noise components that do not correlate to each other can be eliminated.

5   Fig. 5 is a flow chart showing a software process that accomplishes the process of the structure shown in Fig. 4. First of all, at step S51, a moving vector is detected between a picture area of a stored picture and a picture area of an input picture at

10   corresponding positions thereof. At step S52, corresponding to the detected moving vector, the position of the stored picture is shifted. The input picture and the stored picture whose position has been shifted are combined and stored (at step S53). At step

15   S54, the stored picture is read from the storing memory and then output.

[Description of Class Categorizing Adaptive Noise Eliminating Circuit]

Next, the class categorizing adaptive noise

20   eliminating circuit according to the embodiment will be described in detail. In the following example, as the class categorizing adaptive process, pixels are categorized as classes corresponding to a three-dimensional (chronological - spatial) distribution of

25   the signal level of the input picture signal. Predictive coefficients that are pre-learnt for individual classes are stored in a memory. Optimally

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estimated values (namely, pixels values from which noise has been eliminated) are output by a calculating process as weighted additions using the obtained predictive coefficients.

5   In the example, the class categorizing adaptive process is performed in consideration of the motion of a picture so as to eliminate noise. In other words, corresponding to a motion estimated with an input picture signal, a pixel area to be referenced for

10   detecting a noise component and a pixel area to be used for a calculating process for eliminating the noise are extracted. Corresponding to the extracted pixel areas, a picture from which noise has been eliminated by the class categorizing adaptive process is output.

15   Fig. 6 shows the overall structure of the class categorizing adaptive noise eliminating circuit according to the embodiment.

An input picture signal to be processed is supplied to a frame memory 21. The frame memory 21

20   stores a picture of the current frame that is supplied. In addition, the frame memory 21 supplies a picture of the preceding frame to a frame memory 22. The frame memory 22 stores a picture of one frame that is supplied. In addition, the frame memory 22 supplies a

25   picture of the preceding frame to a frame memory 23. In such a manner, pictures of later frames are successively stored to the frame memories 21, 22, and

23.

In the following description, it is assumed
that the frame memory 22 stores a picture of the
current frame, the frame memory 21 stores a picture of
5   the next frame of the current frame, and the frame
memory 23 stores a picture of the preceding frame of
the current frame.

It should be noted that the contents stored
in the frame memories 21, 22, and 23 are not limited to
10   the above-described example. Alternatively, pictures
may be stored to the frame memories 21, 22, and 23 at
intervals of two frames each. Further alternatively,
five frame memories may be disposed so as to store
pictures of five successive frames instead of the three
15   successive frames. Further alternatively, field
memories may be used instead of frame memories.

Picture data of the next frame, the current
frame, and the preceding frame stored in the frame
memories 21, 22, and 23 is supplied to a moving vector
20   detecting portion 24, a moving vector detecting portion
25, a first area extracting portion 26, and a second
area extracting portion 27, respectively.

The moving vector detecting portion 24
detects a moving vector between a considered pixel of a
25   picture of the current frame stored in the frame memory
22 and a considered pixel of a picture of the preceding
frame stored in the frame memory 23 at corresponding

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positions of the pictures. The moving vector detecting portion 25 detects a moving vector between a considered pixel of a picture of the current frame stored in the frame memory 22 and a considered pixel of the picture of the next frame stored in the frame memory 21 at corresponding positions of the pictures.

The moving vectors (moving directions and moving amounts) of the considered pixels detected by the moving vector detecting portions 24 and 25 are supplied to the first area extracting portion 26 and the second area extracting portion 27, respectively. As examples of the method for detecting the moving vectors, block matching method, estimating method using correlated coefficients, slope method, and so forth can be used.

While referencing the moving vectors detected by the moving vector detecting portions 24 and 25, the first area extracting portion 26 extracts pixels at predetermined positions (that will be described later) of the picture data of the individual frames and supplies the values of the extracted pixels to a feature detecting portion 28.

Corresponding to an output of the first area extracting portion 26, the feature detecting portion 28 generates class code that represents information of a noise component as will be described later and supplies the generated class code to a coefficient ROM 29.

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Since the pixels extracted by the first area extracting portion 26 are used to generate class code, these pixels are referred to as class taps.

The coefficient ROM 29 pre-stores predictive coefficients that are learnt (that will be described later) corresponding to individual classes (more practically, corresponding to addresses with respect to the class code). The coefficient ROM 29 receives as addresses the class code supplied from the feature detecting portion 28 and outputs corresponding predictive coefficients.

On the other hand, the second area extracting portion 27 extracts pixels to be predicted from picture data of three successive frames stored in the frame memories 21, 22, and 23 and supplies the values of the extracted pixels to an estimation calculating portion 30. The estimation calculating portion 30 performs a weighted calculation expressed by the following formula (1) corresponding to the output of the second area extracting portion 27 and the predictive coefficients that are read from the coefficient ROM 29 and generates a predicted picture signal from which noise has been eliminated. Since the pixel values extracted by the second area extracting portion 27 are used in weighted additions for generating the predictive picture signal, these pixel values are referred to as predictive taps.

$$y = w_1 \times x_1 + w_2 \times x_2 + \ldots + w_n \times x_n$$

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where x_1, x_2, ..., x_n represent predictive taps; w_1,

w_2, ..., w_n represent predictive coefficients.

Fig. 7 shows tap structures of class taps and

predictive taps extracted by the first area extracting

portion 26 and the second area extracting portion 27,

respectively. In Fig. 7, a considered pixel to be

predicted is denoted by a black circle, whereas pixels

extracted as class taps or predictive taps are denoted

by shaded circles. Fig. 7A shows an example of the

basic structure of class taps. From a current frame

f[0] containing a considered pixel, a frame

chronologically preceded by the current frame (namely,

a preceding frame f[-1]), and a frame chronologically

followed by the current frame (namely, a next frame

f[+1]), pixels at positions spatially corresponding to

the considered pixel are extracted as class taps.

In other words, in the tap structure of this

example, as class taps, one pixel is extracted from the

preceding frame f[-1], the current frame f[0], and the

next frame [+1] each.

When the moving vectors of the considered

pixels detected by the moving vector detecting portion

24 and the moving vector detecting portion 25 are

remarkably small, the considered pixels are determined

as still portions. In this case, pixels at

corresponding positions of the preceding frame f[-1],

the current frame f[0], and the next frame f[+1] are extracted as class taps used for detecting noise. Thus, the pixel positions of the class taps of the individual frames to be processed are constant. Thus, the tap structure does not vary.

On the other hand, when the motion of considered pixels is large to some extent and it is determined that the considered pixels are a moving portion, the first area extracting portion 26 extracts pixels at positions corresponding to the considered pixels from the preceding frame f[-1], the current frame f[0], and the next frame f[+1] as class taps. In other words, pixels at positions corresponding to the moving vector are extracted. The position of a pixel extracted from picture data of the next frame f[+1] is decided with a moving vector detected by the moving vector detecting portion 24. The position of a pixel extracted from picture data of the preceding frame f[-1] is decided with a moving vector detected by the moving vector detecting portion 25.

Fig. 7B shows an example of the basic structure of predictive taps extracted by the second area extracting portion 27. A total of 13 pixels including a considered pixel and for example 12 pixels adjacent thereto are extracted as predictive taps from picture data of a considered frame and picture data of frames that chronologically follow and precede the

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considered frame.

Fig. 7C and Fig. 7D show the case that the extracting positions are chronologically moved corresponding to moving vectors that are output from the moving vector detecting portions 24 and 25. As shown in Fig. 7E, when a moving vector of a considered frame is (0, 0), a moving vector of the preceding frame is (-1, -1), and a moving vector of the next frame is (1, 1), the extracting positions of class taps and predictive taps of all the frames are moved in parallel corresponding to the moving vectors.

As predictive taps, the same tap structure as class taps may be used.

As the result of extracted pixels corresponding to the moving vectors, class taps extracted by the first area extracting portion 26 are pixels at corresponding positions of pictures of a plurality of frames. Likewise, predictive taps extracted by the second area extracting portion 27 are pixels at corresponding positions of pictures of a plurality of frames since the motion of the pictures is compensated.

Alternatively, a tap structure of which the number of frame memories is five instead of three may be used. In this case, the frame memories store a current frame, two preceding frames, and two next frames. A considered pixel is extracted from only the

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current frame and pixels at corresponding positions of
the considered pixel are extracted from the two
preceding frames and the two next frames. In this case,
since the pixel area from which pixels are extracted is

5   chronologically extended, noise can be more effectively
eliminated.

As will be described later, the feature
detecting portion 28 detects the variation of the level
of a noise component of a considered pixel

10   corresponding to the variation of pixel values of
pixels of three frames extracted as class taps. The
feature detecting portion 28 outputs class code
corresponding to the variation of the level of the
noise component to the coefficient ROM 29. In other

15   words, the feature detecting portion 28 categorizes the
variation of the level of a noise component of a
considered pixel as a class and outputs class code that
represents the categorized class.

According to the embodiment, the feature

20   detecting portion 28 performs ADRC (Adaptive Dynamic
Range Coding) for an output of the first area
extracting portion 26 and generates class code as the
variation of the levels of pixels at corresponding
position of a considered pixel of a plurality of frames.

25   Fig. 8 shows an example of the feature
detecting portion 28. In Fig. 8, class code is
generated by one-bit ADRC.

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As was described above, a total of three
pixels that are a considered pixel of the current frame,
a pixel of the preceding frame, and a pixel of the next
frame at corresponding positions of these frames are

5   supplied from the frame memories 21, 22, and 23 to a
dynamic range detecting circuit 281. The value of each
pixel is represented by for example eight bits. The
dynamic range detecting circuit 281 detects the maximum
value MAX and the minimum value MIN of the three pixels,

10   calculates MAX - MIN = DR, and obtains the dynamic
range DR.

The dynamic range detecting circuit 281
outputs the calculated dynamic range DR, the minimum
value MIN, and the pixel values Px of the three input

15   pixels.

The pixel values Px of the three pixels are
successively supplied from the dynamic range detecting
circuit 281 to a subtracting circuit 282. The
subtracting circuit 282 subtracts the minimum value MIN

20   from each of the pixel values Px. As a result,
normalized pixel values of which the minimum value MIN
has been subtracted from each of the pixel values Px
are supplied to a comparing circuit 283.

An output (DR / 2) of a bit shifting circuit

25   284 that divides the dynamic range DR by 2 is supplied
to the comparing circuit 283. The comparing circuit
283 detects the relation of each of the pixel values Px

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and DR / 2. When each of the pixel values Px is larger
than DR / 2, the compared output of one bit of the
comparing circuit 283 becomes "1". Otherwise, the
compared output is "0". The comparing circuit 283
arranges the compared outputs of three bits in parallel
and generates a three-bit ADRC output.

The dynamic range DR is supplied to a "number
of bits" converting circuit 285. The "number of bits"
converting circuit 285 converts eight bits of the
dynamic range DR into for example three bits by
quantization. The converted dynamic range and the
three-bit ADRC output are supplied as class code to the
coefficient ROM 29.

In the above-described class tap structure,
the pixel values of the considered pixel of the current
frame and the corresponding pixels of the preceding
frame and the next frame do not vary. Alternatively,
they tend to slightly vary. Thus, when they vary, it
can be determined that they result from noise.

For example, in the case shown in Fig. 9,
when pixel values of class taps extracted from frames
at t - 1, t, and t + 1 that are chronologically
successive are processed by one-bit ADRC, an ADRC
output of three bits [010] is generated. The dynamic
range DR of which eight bits have been converted into
five bits is output. The ADRC output of three bits
represents the variation of the noise level of the

considered pixel.

When multi-bit ADRC is performed instead of one-bit ADRC, the variation of the noise level can be more accurately represented. The noise level is

5   represented by the dynamic range DR of which eight bits have been converted into five bits. By converting eight bits of the dynamic range DR into five bits, the number of classes can be prevented from being too large.

The class code generated by the feature

10   detecting portion 28 contains code of for example three bits as for the variation of noise level in the chronological direction obtained as the result of ADRC and code of for example five bits as for the noise level as the result of the dynamic range DR. Since the

15   dynamic range DR is used to categorize pixels as classes, a motion can be distinguished from noise. In addition, noise levels can be distinguished.

Next, with reference to Fig. 10, a learning process of which predictive coefficients stored to the

20   coefficient ROM 29 are obtained will be described. For simplicity, in Fig. 10, similar structural elements to those in Fig. 6 will be denoted by similar reference numerals.

An input picture signal that does not contain

25   noise (this signal is referred to as teacher signal) is used for a learning and supplied to a noise adding portion 31 and a normal equation adding portion 32.

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The noise adding portion 31 adds a noise component to the input picture signal and generates a noise added picture (referred to as student signal). The generated student signal is supplied to a frame memory 21. As

5 was described with reference to Fig. 6, pictures of student signals of three frames that are chronologically successive are stored to the frame memories 21, 22, and 23.

In the following description, it is assumed

10 that the frame memory 22 stores a picture of the current frame, the frame memory 21 stores a picture of the next frame, and the frame memory 23 stores a picture of the preceding frame. As mentioned above, however, it should be noted that the contents stored in

15 the frame memories 21, 22, and 23 are not limited to such pictures.

On the next stages of the frame memories 21, 22, and 23, almost the same processes as those described with reference to Fig. 6 are performed. In

20 Fig. 10, similar blocks to those in Fig. 6 will be denoted by similar reference numerals. The class code generated by a feature detecting portion 28 and predictive taps extracted by a second area extracting portion 27 are supplied to a normal equation adding

25 portion 32. In addition, a teacher signal is supplied to the normal equation adding portion 32. To generate coefficients corresponding to the three types of inputs,

the normal equation adding portion 32 performs a process for generating a normal equation. A predictive coefficient deciding portion 33 decides predictive coefficients for each class code using the normal equation. The predictive coefficient deciding portion 33 supplies the decided predictive coefficients to a memory 34. The memory 34 stores the supplied predictive coefficients corresponding to the individual classes. The predictive coefficients stored in the memory 34 are the same as the predictive coefficients stored in the coefficient ROM 29 (see Fig. 6).

Next, a normal equation will be described. In the formula (1), before predictive coefficients w_1, ..., and w_n are learnt, they are indeterminate coefficients. The predictive coefficients are learnt by inputting a plurality of teacher signals corresponding to individual classes. When the number of types of teacher signals per class is denoted by m, the formula (2) can be obtained from the formula (1).

$$y_k = w_1 \times x_{k1} + w_2 \times x_{k2} + \ldots + w_n \times x_{kn}$$

$$\ldots (2)$$

(where $k = 1, 2, \ldots, m$)

When $m > n$, since the predictive coefficients w_1, ..., and w_n are not uniquely designated, elements e_k of an error vector e are defined by the following formula (3).

$$e_k = y_k - \{w_1 \times w_{k1} + w_2 \times x_{k2} + \ldots + w_n \times$$

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x_{kn}}

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ ... (3)

(where k = 1, 2, ..., m)

The predictive coefficients are designated in such a manner that the error vector e defined by the following formula (4) becomes minimum. In other words, the predictive coefficients are uniquely designated using so-called method of least squares.

$$e^2 = \sum_{k=0}^{m} e_k^2 \qquad\qquad\qquad \ldots (4)$$

As a practical calculating method for obtaining the predictive coefficients of which e^2 of the formula (4) becomes minimum, each predictive coefficient w_i is obtained by partially differentiating e^2 with respect to the predictive coefficients w_i (where i = 1, 2, ...) (formula (5)) so that the partially differentiated value of each value of i becomes 0.

$$\frac{\partial e^2}{\partial w_i} = \sum_{k=0}^{m} 2\left(\frac{\partial e_k}{\partial w_i}\right) e_k = \sum_{k=0}^{m} 2x_{ki}\, e_k \qquad \ldots (5)$$

Next, a practical process for designating each predictive coefficient w_i using the formula (5) will be described. When X_{ji} and Y_i are defined as the following formulas (6) and (7), respectively, the formula (5) can be expressed as the following formula (8) in a matrix form.

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$$X_{ji} = \sum_{p=0}^{m} x_{pi} \cdot x_{pj} \qquad \dots (6)$$

$$Y_i = \sum_{k=0}^{m} x_{ki} \cdot y_k \qquad \dots (7)$$

$$\begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{n1} & x_{n2} & \dots & x_{nm} \end{bmatrix} \begin{bmatrix} W_1 \\ W_2 \\ \dots \\ W_n \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \\ \dots \\ Y_n \end{bmatrix} \qquad \dots (8)$$

The formula (8) is generally referred to as normal equation. The predictive coefficient deciding portion 33 calculates each parameter of the normal equation (8) corresponding to the above-mentioned three types of inputs. In addition, the predictive coefficient deciding portion 33 calculate the predictive coefficients w_i by a calculating process for solving the normal equation (8) using a conventional matrix solving method such as sweep-out method.

When the noise adding portion 31 adds noise, one of the following four methods can be used.

1.   As with a computer simulation, random noise is generated and added to an input picture signal.

2.   Noise is added to an input picture signal through an RF system.

3.   A noise component is extracted as the difference between a plain picture signal that does not largely vary and a signal of which the picture signal has been processed through an RF system. The extracted

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noise component is added to the input picture signal.

4. A noise component is extracted as the difference between a signal of which a plain picture signal has been processed through an RF system and a picture signal component of which noise has been eliminated by adding such a signal to a plurality of frames. The extracted noise component is added to an input picture signal.

When the noise eliminating circuit 12 using the above-mentioned class categorizing adaptive process performs the class categorizing adaptive process for eliminating noise from a picture signal, the noise eliminating circuit 12 extracts a considered pixel and pixels at corresponding positions thereof as class taps, detects the variation of the noise level among frames corresponding to the data of the class taps, and generates class code corresponding to the detected variation of the noise level.

Thereafter, a motion among the frames is estimated. Pixels to be used in the noise component detecting process (these pixels are referred to as class taps) and pixels to be used in the predictive calculating process (these pixels are referred to as predictive taps) are extracted so that the estimated motion is compensated. Corresponding to each class of which a noise component has been reflected, by a linear combination of predictive taps and predictive

coefficients, a picture signal from which noise has been eliminated is calculated.

Thus, predictive coefficients that accurately correspond to the variation of the noise component among frames can be selected. Thus, using such predictive coefficients, a predictive calculation is performed. As a result, the noise component can be adequately eliminated.

In addition, even if a picture moves among frames, the noise level can be correctly detected. Thus, the noise can be eliminated. In particular, a picture can be prevented from becoming unsharp against a mistaken determination of a motion adaptive type recursive filter that mistakenly determines that a moving portion is a still portion as was described with reference to Fig. 1.

In a class tap structure of which class taps do not spatially spread in a frame (namely, a tap structure of which only a considered pixel is extracted from the current frame and a pixel at a corresponding position of the considered pixel is extracted from a frame chronologically followed/ preceded by the current frame is used as class taps and/or predictive taps), a factor that causes a picture signal in the spatial direction to become unsharp can be suppressed from adversely affecting the process. In other words, the situation of which for example an edge causes an output

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picture signal to become unsharp can be suppressed.

As was described above, the class
categorizing adaptive noise eliminating circuit 12
eliminates noise regardless of whether a picture is

5   still or moving. However, when a picture is a perfect
still portion, the class categorizing adaptive noise
eliminating circuit 12 is inferior to the motion
adaptive type recursive filter that can store
information of a long frame.

10   As was described above, according to the
present invention, when a picture is a still portion,
an output of the motion adaptive type recursive filter
shown in Fig. 1 or Fig. 4 is selected and output. In
contrast, when a picture is a moving portion, an output

15   of the class categorizing adaptive noise eliminating
circuit is selected and output. Thus, regardless of
whether a picture is a moving portion or a still
portion, an output picture signal from which noise has
been adequately eliminated can be obtained.

20   It should be noted that class taps and
predictive taps of the first area extracting portion 26
and the second area extracting portion 27 in the
description of the class categorizing adaptive
eliminating circuit are only examples. In other words,

25   the present invention is not limited to such class taps
and predictive taps.

In the above description, the feature

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detecting portion 28 uses a one-bit ADRC encode circuit. Alternatively, as was mentioned above, the feature detecting portion 28 may use a multi-bit ADRC encode circuit. Further alternatively, the feature detecting

5   portion 28 may use a non-ADRC encode circuit.

In the above description, an output of the motion adaptive type recursive filter 11 or an output of the class categorizing adaptive noise eliminating circuit 12 is selected pixel by pixel. Alternatively,

10   instead of each pixel, such an output may be selected for each pixel block (composed of a predetermined number of pixels), each object, or each frame. In this case, the still portion - moving portion determining circuit determines whether each pixel block, each

15   object, or each frame is a still portion or a moving portion.

In the above-described example, an alternative section of which an output of one motion adaptive type recursive filter or an output of one

20   class categorizing adaptive eliminating circuit is selected was used. Alternatively, a plurality of motion adaptive type recursive filters and/or a plurality of noise eliminating circuits using the class categorizing adaptive process may be disposed and one

25   output picture signal may be selected therefrom.

The embodiment of the present invention can be accomplished by software as well as hardware. Next,

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a process of the embodiment of the present invention
accomplished by software will be explained. Fig. 11 is
a flow chart showing a noise eliminating process
according to the embodiment of the present invention.
As shown at steps S1 and S2, a class categorizing
adaptive noise eliminating process and a motion
adaptive type recursive filter process are performed in
parallel. The difference between the results obtained
in these processes is calculated (at step S3).

At step S4, the absolute value of the
difference is calculated. At step S5, it is determined
whether or not the absolute value of the difference is
large. When the determined result represents that the
absolute value of the difference is large, an output of
the class categorizing adaptive noise eliminating
process is selected (at step S6). Otherwise, an output
of the motion adaptive type recursive filter is
selected (at step S7). As a result, the noise
eliminating process for one pixel is completed.

Fig. 12 is a flow chart showing the detail of
the motion adaptive type recursive filter process at
step S2. At step S11, an initial input picture is
stored to a frame memory. At step S12, the difference
(frame difference) of the picture stored in the frame
memory and the next input picture is calculated. At
step S13, the absolute value of the difference is
calculated.

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At step S14, the absolute value of the difference is compared with a predetermined threshold value. When the absolute value of the difference is equal to or larger than the threshold value, a weighting coefficient k by which the input picture signal is designated to 1 (at step S15). In other words, since the input picture signal is a moving portion, a weighting coefficient (1 - k) by which the output signal of the frame memory is multiplied is designated to 0. In contrast, when the absolute value of the difference is smaller than the threshold value, at step S16, k is designated to a value in the range of (0 to 0.5).

Thereafter, a pixel stored in the frame memory and a pixel at a corresponding position of the next input picture are weighted and added (at step S17). The added result is stored to the frame memory (at step S18). Thereafter, the flow returns to step S12. Thereafter, the added result is output (at step S19).

Fig. 13 is a flow chart showing the detail of the class categorizing adaptive noise eliminating process at step S1. First of all, at step S21, a moving vector between the current frame and the preceding frame is detected. At step S22, a moving vector between the current frame and the next frame is detected. At step S23, a first area is extracted. In other words, class taps are extracted. At step S24, a

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feature detecting process is performed for the
extracted class taps. Coefficients corresponding to a
detected feature are read from coefficients that have
been obtained by a learning process (at step S25).

5   At step S26, a second area (predictive taps)
is extracted. At step S27, an estimating calculation
is performed using the coefficients and predictive taps.
As a result, an output from which noise has been
eliminated is obtained. In the first area extracting

10   process (at step S23) and the second area extracting
process (at step S26), the extracting positions are
changed corresponding to the moving vectors detected at
steps S21 and S22, respectively.

          Fig. 14 is a flow chart showing a learning

15   process for obtaining coefficients used in the class
categorizing adaptive noise eliminating process. At
step S31, noise is added to a picture signal that does
not contain noise (this signal is referred to as
teacher signal). As a result, a student signal is

20   generated. At step S32, with respect to the student
signal, a moving vector between the current frame and
the preceding frame is detected. At step S33, a moving
vector between the current frame and the next frame is
detected. Area extracting positions are changed

25   corresponding to the detected moving vectors.

          At step S34, a first area (class taps) is
extracted. A feature is detected corresponding to the

extracted class taps (at step S35). At step S36, a
second area (predictive taps) is extracted. At step
S37, data necessary for solving a normal equation with
which predictive coefficients are solved is calculated

5   with the teacher picture signal, data of the predictive
taps, and the detected feature.

At step S38, it is determined whether or not
additions of the normal equation have been completed.
When the additions have not been completed, the flow

10   returns to step S31. When the determined result
represents that the process has been completed, at step
S39, predictive coefficients are decided. The obtained
predictive coefficients are stored in a memory. The
predictive coefficients stored in the memory are used

15   for the noise eliminating process.

As was described above, with the noise
eliminating circuit according to the present invention,
when a picture is a still portion, an output of the
noise eliminating circuit that has a large noise

20   eliminating effect for a still portion such as a motion
adaptive type recursive filter is selected. When a
picture is a moving portion, an output of a noise
eliminating circuit such as a class categorizing
adaptive noise eliminating circuit that can eliminate

25   noise of a moving portion is selected. Thus,
regardless of whether a picture is a moving portion or
a still portion, a picture signal output from which

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noise has been adequately eliminated can be obtained.

Next, with reference to drawings from Fig. 15, a resolution converting apparatus that performs an upconvert will be described as another embodiment of

5   the present invention. According to the other embodiment, an above-mentioned standard television format (hereinafter referred to as SD) picture signal as an input picture signal is converted into an output picture signal in a high vision format (hereinafter

10   referred to as HD). According to the other embodiment, as shown in Fig. 16, for each considered pixel of an SD picture, four pixels of an HD picture are generated so as to convert the resolution of the input picture signal.

15   Fig. 15 is a block diagram showing the structure of the other embodiment. As shown in Fig. 15, an input picture signal is supplied pixel by pixel to a high density storage resolution converting circuit 111 that composes an example of the resolution converting

20   portion using the storage type process. In addition, the input picture signal is supplied to a class categorizing adaptive process resolution converting circuit 112 that composes an example of the resolution converting portion using the class categorizing

25   adaptive process.

The high density storage resolution converting circuit 111 has a frame memory that stores a

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picture signal of an HD equivalent picture. The high
density storage resolution converting circuit 111
references a motion between a picture of a picture
signal stored in the frame memory and a picture of an
5   SD input picture signal, compensates the pixel
positions, and stores the SD input picture signal to
the frame memory so as to generate an output picture
signal of an HD equivalent picture in the frame memory.
The detailed structure of the high density storage
10   resolution converting circuit 111 will be described
later. The converted picture signal of the HD
equivalent picture generated by the high density
storage resolution converting circuit 111 is supplied
to an output selecting portion 113.

15   In contrast, the class categorizing adaptive
process resolution converting circuit 112 detects a
feature of a considered pixel of a picture of an SD
input picture signal from a plurality of pixels
including the considered pixel and pixels
20   chronologically and spatially adjacent thereto. The
class categorizing adaptive process resolution
converting circuit 112 categorizes the considered pixel
as a class corresponding to the detected feature and
generates a plurality of pixels of an HD picture
25   corresponding to the considered pixel by a
predetermined picture conversion calculating process
corresponding to the categorized class so as to

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generate a high resolution output picture signal. The detailed structure of the class categorizing adaptive process resolution converting circuit 112 will be described later. The converted picture signal of the HD equivalent picture generated by the class categorizing adaptive process resolution converting circuit 112 is supplied to an output selecting portion 113.

The output selecting portion 113 is composed of a determining circuit 114 and a selecting circuit 115 that will be described later. The converted picture signal supplied from the high density storage resolution converting circuit 111 and the converted picture signal supplied from the class categorizing adaptive process resolution converting circuit 112 are supplied to the selecting circuit 115.

The converted picture signal supplied from the high density storage resolution converting circuit 111 and the converted picture signal supplied from the class categorizing adaptive process resolution converting circuit 112 are supplied to the determining circuit 114. The determining circuit 114 determines a motion and an activity of each of the two converted picture signals in the unit of a predetermined number of pixels. The determining circuit 114 generates a selection control signal that causes one of the converted picture signal supplied from the high density

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storage resolution converting circuit 111 and the
converted picture signal supplied from the class
categorizing adaptive process resolution converting
circuit 112 to be selected in the unit of a

5   predetermined number of pixels. In the example, the
determining circuit 114 determines which of the two
converted picture signals is selected for each pixel
and supplies the determined result as a selection
control signal to the selecting circuit 115.

10   [Example of Structure of High Density Storage
Resolution Converting Circuit]

        Fig. 17 shows an example of the structure of
the high density storage resolution converting circuit
111 according to the other embodiment. The high

15   density storage resolution converting circuit 111 is
effective for converting the resolution of a picture
into another resolution when the picture is a still
picture or a moving picture that has a simple motion
such as a pan or a tilt except for a scene change or a

20   zoom.

        As shown in Fig. 17, the high density storage
resolution converting circuit 111 has a frame memory
210. The frame memory 210 stores each pixel value of a
picture signal of one frame having a resolution of an

25   HD equivalent picture (see Fig. 16).

        First of all, an SD input picture signal is
supplied to a linear interpolating portion 211. The

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linear interpolating portion 211 performs a linear

interpolation for the SD input picture signal so as to

generate a picture signal having pixels equivalent to

an HD picture with the SD input picture signal and

5   outputs the generated picture signal to a moving vector

detecting portion 212. When a moving vector between

the SD input picture and the HD equivalent picture

stored in the frame memory 210 is detected, the linear

interpolating portion 211 performs the process in such

10   a manner that the size of the SD input picture is

matched with the size of the HD equivalent picture.

The moving vector detecting portion 212

detects a moving vector between an output picture of

the linear interpolating portion 211 and the HD

15   equivalent picture stored in the frame memory 210. The

moving vector is detected by matching representative

points on full screens. In this case, the accuracy of

the detected moving vector of the HD equivalent picture

is one pixel. Thus, the accuracy of the detected

20   moving vector of the SD input picture signal is less

than one pixel.

The moving vector detected by the moving

vector detecting portion 212 is supplied to a phase

shifting portion 213. Corresponding to the supplied

25   moving vector, the phase shifting portion 213 shifts

the phase of the SD input picture signal. The phase

shifting portion 213 supplies the resultant SD input

picture signal to a picture storage processing portion
214. The picture storage processing portion 214
performs a storing process for the picture signal
stored in the frame memory 210 and the SD input picture
5   signal that has been phase-shifted by the phase
shifting portion 213. The stored contents of the frame
memory 210 are rewritten with the picture signal for
which the storing process has been performed.

Figs. 18 and 19 are schematic diagrams
10   showing the concept of the process performed by the
picture storage processing portion 214. For simplicity,
Figs. 18 and 19 show a storage process in only the
vertical direction. However, in addition, the storage
process is performed in the horizontal direction.

15   Figs. 18A and 19A show an SD input picture
signal. In Fig. 19, black circles represent real
pixels of an SD picture, whereas white circles
represent pixels that do not exist. In the example
shown in Fig. 19, since the moving vector detecting
20   portion 212 has detected a motion for three pixels in
the vertical direction of an HD equivalent picture, the
phase shifting portion 213 shifts the phases of three
pixels in the vertical direction of an SD input picture
signal. As mentioned above, since the accuracy of the
25   detected moving vector is one pixel of an HD equivalent
picture, as shown in Fig. 19B, the positions of the
pixels of the SD input picture signal whose phases have

been shifted correspond to the positions of pixels of the picture signal of the HD equivalent picture stored in the frame memory 210.

In the picture storage process, each pixel whose phase has been shifted and each corresponding pixel of the HD equivalent picture signal (see Fig. 18B and Fig. 19C) stored in the frame memory 210 are added and then the average value thereof is obtained. Thereafter, with each added output pixel, each corresponding pixel stored in the frame memory 210 is rewritten. In other words, when an SD picture has a motion, it is compensated. Each pixel of the HD storage picture and each corresponding pixel of the SD input picture are added. In this case, the HD storage picture and the SD input picture to be added may be weighted.

By the picture storage process, the original SD picture is shifted corresponding to a moving vector with an accuracy of one pixel of the HD picture and then stored in the frame memory 210. Thus, corresponding to the SD picture shown in Fig. 19A, the HD equivalent picture shown in Fig. 18B or Fig. 19C is stored in the frame memory 210. Fig. 18 and Fig. 19 are schematic diagrams for explaining the picture storage process in only the vertical direction. However, the SD picture is also converted into the HD equivalent picture in the horizontal direction as well

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as the vertical direction.

The picture signal stored as an HD output picture signal in the frame memory 210 by the above-described storage process is supplied to the output

5 selecting portion 113 as an output of the high density storage resolution converting circuit 111. Since the HD output picture signal that is output from the high density storage resolution converting circuit 111 is generated by the above-mentioned high density storage

10 process for the picture in the chronological direction, when the SD input picture is a still picture portion or a moving picture portion moving picture that has a simple motion such as a pan or a tilt except for a scene change or a zoom, an HD output picture that less

15 deteriorates and that does not have a folded distortion can be obtained.

However, when the SD input picture is a moving picture portion that has a large moving portion such as a scene change or a zoom, a class categorizing

20 adaptive process resolution converting circuit that performs an SD - HD conversion in the unit of a predetermined number of pixels that is more than one pixel can output an HD output picture with high quality as will be described later.

25 [Example of Structure of Class Categorizing Adaptive Process Resolution Converting Circuit]

Next, the class categorizing adaptive process

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resolution converting circuit 112 according to the other embodiment will be described in detail. In the following example, in the class categorizing adaptive process, a considered pixel of an SD input picture

5   signal is categorized as a class corresponding to a feature thereof. Predictive coefficients that have been learnt for individual classes are stored in a memory. By a calculating process corresponding to weighted additions using the predictive coefficients,

10   optimally estimated pixel values of a plurality of HD pixels corresponding to the considered pixel are output.

Fig. 20 shows an example of the overall structure of the class categorizing adaptive process resolution converting circuit 112 according to the

15   other embodiment.

An SD input picture signal to be processed is supplied to a field memory 221. The field memory 221 always stores an SD picture signal of the preceding field. The SD input picture signal and the SD picture

20   signal of the preceding field stored in the field memory 221 are supplied to a first area extracting portion 222 and a second area extracting portion 223.

The first area extracting portion 222 performs a process for considering a plurality of

25   pixels from the SD input picture signal and the SD picture signal so as to extract a feature of a considered pixel of the SD input picture signal (as

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will be described later, these pixels are referred to as class taps).

The first area extracting portion 222 supplies the pixel values of the extracted pixels to a feature detecting portion 224. The feature detecting portion 224 generates class code that represents the feature of the considered pixel using the considered pixel of the first area and pixels chronologically and spatially adjacent thereto. The feature detecting portion 224 supplies the generated class code to a coefficient ROM 225. Since the plurality of pixels extracted by the first area extracting portion 222 are used to generate the class code, they are referred to as class taps.

The coefficient ROM 225 pre-stores predictive coefficients for individual classes that are leant as will be described later (in reality, at addresses corresponding to class code). The coefficient ROM 225 receives the class code as an address from the feature detecting portion 224 and outputs corresponding predictive coefficients.

On the other hand, the second area extracting portion 223 extracts a plurality of predictive pixels including a considered pixel in a predictive pixel area (second area) from the SD input picture signal and the SD picture signal of the preceding frame stored in the field memory 221 and supplies the values of the

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extracted pixels to an estimation calculating portion 226.

The estimation calculating portion 226 performs a calculation expressed by the following formula (11) with the pixel values of the plurality of predictive pixels extracted by the second area extracting portion 223 and the predictive coefficients that are read from the coefficient ROM 225, obtains the pixel values of the plurality of pixels of the HD picture corresponding to the considered pixel of the SD picture, and generates a predictive HD picture signal. Thus, since the pixel values extracted by the second area extracting portion 223 are used for weighted additions to generate the predictive HD picture signal, these pixel values are referred to as predictive taps. The formula (11) is the same as the formula (1) according to the above-described embodiment.

$$y = w_1 \times x_1 + w_2 \times x_2 + \ldots + w_n \times x_n$$

$$\ldots (11)$$

where x_1, x_2, ..., and x_n represent predictive taps; and w_1, w_2, ..., and w_n represent predictive coefficients.

Next, with reference to Fig. 21, an example of class taps extracted by the first area extracting portion 222 will be described. In the example, a plurality of pixels are extracted as class taps as shown in Fig. 21. Fig. 21 shows a field that contains

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a considered pixel and a field preceded thereby.

In Fig. 21, black circles represent pixels of an n-th field (for example, an odd field), whereas white circles represent pixels of an (n + 1)-th field (for example, an even field). Class taps are composed of a considered pixel and a plurality of pixels chronologically and spatially adjacent thereto.

When a considered pixel is a pixel of the n-th field, class taps are structured as shown in Fig. 21A. From the n-th field, a considered pixel, a pixel at an upper position of the considered pixel, a pixel at a lower position of the considered pixel, two pixels on the left positions of the considered pixel, and two pixels on the right positions of the considered pixel are extracted as class taps. From the preceding field, six pixels spatially adjacent to the considered pixel are extracted as class taps. Thus, a total of 13 pixels are extracted as class taps.

In contrast, when the considered pixel is a pixel of the (n + 1)-th field, class taps are structured as shown in Fig. 21B. From the (n + 1)-th field, a considered pixel, a pixel on the left of the considered pixel, and a pixel on the right of the considered pixel are extracted as class taps. From the preceding field, six pixels spatially adjacent to the considered pixel are extracted as class taps. Thus, a total of nine pixels are extracted as class taps. In

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this example, predictive taps extracted by the second
area extracting portion 27 are structured as with the
above-described class taps.

Next, an example of the structure of the
5   feature detecting portion 224 will be described.
According to the other embodiment, a pattern of a
plurality of pixel values extracted as class taps by
the first area extracting portion 222 is used as a
feature of a considered pixel. Although there are a
10   plurality of patterns corresponding to class taps, each
pattern of pixel values is treated as one class.

The feature detecting portion 224 categorizes
a feature of a considered pixel as a class using a
plurality of pixel values extracted as class taps by
15   the first area extracting portion 222 and outputs class
code that represents the categorized class
corresponding to the class taps.

According to the other embodiment, the
feature detecting portion 224 performs ADRC (Adaptive
20   Dynamic Range Coding) for the output of the first area
extracting portion 222 and generates the ADRC output as
class code that represents a feature of a considered
pixel.

Fig. 22 shows an example of the feature
25   detecting portion 224. Fig. 22 generates class code by
one-bit ADRC.

As mentioned above, 13 or 9 pixels as class

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taps are supplied from the first area extracting

portion 222 to a dynamic range detecting circuit 121.

The value of each pixel is represented by for example

eight bits. The dynamic range detecting circuit 121

5   detects the maximum value MAX and the minimum value MIN

of the plurality of pixels as the class taps,

calculates MAX - MIN = DR, and obtains the dynamic

range DR.

The dynamic range detecting circuit 121

10   outputs the calculated dynamic range DR, the minimum

value MIN, and pixel values Px of the plurality of

pixels that are input.

The pixel values Px of the plurality of

pixels are successively supplied from the dynamic range

15   detecting circuit 121 to a subtracting circuit 22. The

subtracting circuit 22 subtracts the minimum value MIN

from each pixel value Px. Since the minimum value MIN

is subtracted from each pixel value Px, a normalized

pixel value is supplied to a comparing circuit 123.

20   An output (DR / 2) of which the dynamic range

DR is divided by 2 is supplied from a bit shifting

circuit 124 to the comparing circuit 123. The

comparing circuit 123 detects the relation of each

pixel value Px and DR / 2. As shown in Fig. 23, when

25   the pixel value Px is larger than DR / 2, the compared

output of one bit of the comparing circuit 123 becomes

"1". Otherwise, the compared output of one bit of the

comparing circuit 123 becomes "0". The comparing
circuit 123 arranges in parallel the compared outputs
of the plurality of pixels as class taps and generates
an ADRC output of 13 bits or 9 bits.

5   In addition, the dynamic range DR is supplied
to a "number of bits" converting circuit 125. The
"number of bits" converting circuit 125 converts eight
bits of the dynamic range DR into for example five bits
by quantization. The converted dynamic range and the
10   ADRC output are supplied as class code to the
coefficient ROM 225.

Of course, when multi-bit ADRC is performed
instead of one-bit ADRC, a feature of a considered
pixel can be more finely categorized as a class.

15   Next, with reference to Fig. 24, a learning
process (namely, a process for obtaining predictive
coefficients stored in the coefficient ROM 225) will be
described. For simplicity, in Fig. 24, similar
structural portions to those of the class categorizing
20   adaptive process resolution converting circuit 112
shown in Fig. 20 will be denoted by similar reference
numerals.

An HD picture signal used for a learning
(this signal is referred to as teacher signal) is
25   supplied to a thin-out processing portion 131 and a
normal equation adding portion 132. The thin-out
processing portion 131 performs a thin-out process for

the HD picture signal, generates an SD picture signal
(referred to as student signal), and supplies the
generated student signal to a field memory 221. As was
described with reference to Fig. 20, the field memory

5   221 stores a student signal of the chronologically
preceding field.

On the next stage of the field memory 221,
almost the same process as that described with
reference to Fig. 20 is performed except that class

10   code generated by a feature detecting portion 224 and
predictive taps extracted by a second area extracting
portion 223 are supplied to a normal equation adding
portion 132. A teacher signal is also supplied to the
normal equation adding portion 132. To generate

15   coefficients using the three types of inputs, the
normal equation adding portion 132 performs a process
for generating a normal equation. A predictive
coefficient deciding portion 133 decides predictive
coefficients for each class code using the normal

20   equation. The predictive coefficient deciding portion
133 supplies the decided predictive coefficients to a
memory 134. The memory 134 stores the supplied
predictive coefficients. The predictive coefficients
stored in the memory 134 are the same as those stored

25   in the coefficient ROM 225 (see Fig. 20).

Since the process for deciding predictive
coefficients w_1, ..., and w_n for each class using the

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above-described formula (11) is the same as that using the formulas (2) to (8) according to the above-described embodiment, the description of the process will be omitted.

5   In such a manner, the class categorizing adaptive process resolution converting circuit 112 categorizes a feature of a considered pixel of an SD picture as a class, performs an estimating calculation using prepared predictive coefficients corresponding to

10   the categorized class, and thereby generates a plurality of pixels of an HD picture corresponding to the considered pixel.

Thus, since predictive coefficients that accurately correspond to a feature of a considered

15   pixel of an SD picture can be selected, when an estimating calculation is performed using such predictive coefficients, a plurality of pixels of an HD picture corresponding to a considered pixel can be adequately generated. In addition, even if an input

20   picture signal has a motion, a converted picture signal that less deteriorates can be obtained.

Thus, in the class categorizing adaptive process resolution converting circuit 112, a converted picture signal that less deteriorates can be obtained

25   regardless of whether an input picture is a still picture or a moving picture. However, as was described above, when an input picture signal is a perfect still

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portion or a simple moving portion such as a pan or a tilt, a converted picture signal that is output from the class categorizing adaptive process resolution converting circuit 112 is inferior to a converted picture signal that is output from the high density storage resolution converting circuit 111 that can store information of a long frame.

According to the other embodiment, using the characteristics of the two resolution converting circuits 111 and 112, an output picture signal whose resolution has been converted can be obtained from the output selecting portion 113 in such a manner that the output picture signal less deteriorates. In the output selecting portion 113, the determining circuit 114 determines which of the two resolution converted outputs is selected. The output selecting portion 113 controls the selecting circuit 115 so that it adequately outputs a picture signal whose resolution has been adequately converted corresponding to the determined output.

Next, returning to Fig. 15, the detail of the determining circuit 114 and a selecting operation corresponding to the determined result will be described.

In the determining circuit 114, a converted picture signal that is output from the high density storage resolution converting circuit 111 and a

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converted picture signal that is output from the class

categorizing adaptive process resolution converting

circuit 112 are supplied to a difference value

.calculating circuit 241. The difference value

5   calculating circuit 241 calculates the difference value.

An absolute value calculating circuit 242 calculates

the absolute value of the difference value and supplies

the absolute value to a comparing and determining

circuit 243.

10   The comparing and determining circuit 243

determines whether or not the absolute value of the

difference value that is output from the absolute value

calculating circuit 242 is larger than a predetermined

value and supplies the determined result to a selection

15   signal generating circuit 249.

When the determined result of the comparing

and determining circuit 243 represents that the

absolute value of the difference value that is output

from the absolute value calculating circuit 242 is

20   larger than the predetermined value, the comparing and

determining circuit 243 supplies the determined result

to the selection signal generating circuit 249. At

that point, the selection signal generating circuit 249

generates a selection control signal that causes the

25   selecting circuit 115 to select a picture signal whose

resolution has been converted, the picture signal being

supplied from the class categorizing adaptive process

resolution converting circuit 112. The selection

signal generating circuit 249 supplies the selection

control signal to the selecting circuit 115.

Such a selection is performed because of the

5   following reason. In other words, as was described

above, in the high density storage resolution

converting circuit 111, when an input picture signal is

a still picture or a moving picture having a simple pan

or a simple tilt, a converted picture signal less

10   deteriorates. In contrast, when an input picture

signal is a moving picture that has a rotation or a

deformation or a moving picture that has a moving

object, a converted picture signal deteriorates. Thus,

when the level of output pixels of a converted picture

15   signal that is output from the high density storage

resolution converting circuit 111 and the level of

output pixels of a converted picture signal that is

output from the class categorizing adaptive process

resolution converting circuit 112 are remarkably

20   different, it is likely that the difference results

from the deterioration of the picture signal.

Thus, when the absolute value of the

difference value calculated by the difference value

calculating circuit 241 is larger than the

25   predetermined threshold value, it is preferred to use a

converted picture signal that is output from the class

categorizing adaptive process resolution converting

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circuit 112 that can deal with a picture having a motion. Thus, as is clear from the above description, the difference value calculating circuit 241, the absolute value calculating circuit 242, and the comparing and determining circuit 243 compose a still picture - moving picture determining circuit.

When the determined result of the comparing and determining circuit 243 represents that the absolute value of the difference value that is output from the absolute value calculating circuit 242 is smaller than the predetermined value, as will be described in the following, the selection signal generating circuit 249 generates a selection control signal that causes a pixel of the converted picture signal that is output from the high density storage resolution converting circuit 111 or a pixel of the converted picture signal that is output from the class categorizing adaptive process resolution converting circuit 112 to be output from the selecting circuit 115 selected whichever the pixel has a larger activity. The selection signal generating circuit 249 supplies the generated selection control signal to the selecting circuit 115. Since a pixel with a higher activity is output, a picture having a larger activity that is not unsharp can be output.

In the example, as a criterion of activity, a dynamic range of a predetermined area of a plurality of

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pixels preceded and followed by a considered pixel of

an SD picture is used against a resolution converted

output picture signal that is an HD equivalent picture.

Thus, in the determining circuit 114, the

5   converted picture signal that is output from the high

density storage resolution converting circuit 111 and

the converted picture signal that is output from the

class categorizing adaptive process resolution

converting circuit 112 are supplied to the area

10   extracting portions 244 and 245 that extract areas in

which activities are calculations, respectively.

As denoted by broken lines of Fig. 25B and

Fig. 25C, the area extracting portions 244 and 245

extract a plurality of pixels preceded and followed by

15   a considered pixel of an SD picture as pixels in

activity calculation areas against output picture

signals of HD equivalent pictures from the high density

storage resolution converting circuit 111 and the class

categorizing adaptive process resolution converting

20   circuit 112, respectively.

The plurality of pixels extracted as the

areas in which the activities are calculated are

supplied to detecting portions 246 and 247 that detect

dynamic ranges as activities. The detecting portions

25   246 and 247 detect activities in the areas (in the

example, dynamic ranges). The detected outputs are

supplied to a comparing circuit 248. The dynamic

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ranges that are output from the detecting portions 246
and 247 are compared. The compared output is supplied
to the selection signal generating circuit 249.

When the determined result of the comparing
5   and determining circuit 243 represents that the
absolute value of the difference value is smaller than
the predetermined threshold value, the selection signal
generating circuit 249 generates a selection control
signal that causes a resolution converted picture
10   signal with a larger dynamic range of a plurality of
pixels extracted as an activity calculation area to be
selected and output corresponding to the compared
result that is output from the comparing circuit 248.
The selection signal generating circuit 249 supplies
15   the generated selection control signal to the selecting
circuit 115.

Next, the operation of the determining
circuit 114 and the selecting circuit 115 will be
further described with reference to a flow chart shown
20   in Fig. 26. The operation of the flow chart shown in
Fig. 26 is equivalent to the case that the determining
circuit 114 is accomplished by a software process. In
the following description, an example of which a proper
one of the output of the high density storage
25   resolution converting circuit 111 and the output of the
class categorizing adaptive process resolution
converting circuit 112 is selected pixel by pixel will

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be described.

First of all, the difference value of corresponding pixels of both the outputs is calculated (at step S101). It is determined whether or not the absolute value of the difference value is larger than a predetermined threshold value (at step S102). When the absolute value is larger than the threshold value, the converted picture signal that is output from the class categorizing adaptive process resolution converting circuit 112 is selected and output (at step S107).

In contrast, when the absolute value of the difference value is small, the activities (in this example, dynamic ranges) of both the outputs are calculated in the unit of the above-described activity calculation area (at steps S103 and S104). Thereafter, the calculated activities are compared (at step S105). A pixel with the larger activity is output (at steps S106 and S108). As a result, a picture having a larger activity (namely, that does not become unsharp) is selected and output.

In the above-described example, as the criterion of the activities, dynamic ranges in the predetermined areas surrounded by dotted liens shown in Fig. 25 were used. However, it should be noted that the present invention is not limited to such dynamic ranges. In other words, variance in a predetermined area, the sum of absolute values of difference values

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of a considered pixel and two pixels adjacent thereto,
or the like may be used.

In the above example, the selecting process
is performed pixel by pixel. However, it should be
5   noted that the selecting process may be performed block
by block, object by object, frame by frame, or the like.

In the above-described example, either an
output of one high density storage type resolution
converting circuit or an output of one class
10   categorizing adaptive process resolution converting
circuit is selected. Alternatively, a plurality of
high density resolution converting circuits and/or a
plurality of class categorizing adaptive process
resolution converting circuit may be disposed and an
15   output picture signal may be selected therefrom.

Class taps and predictive taps of the first
area extracting portion 222 and the second area
extracting portion 223 described in the section of the
class categorizing adaptive process are just an example.
20   In other words, it is clear that the present invention
is not limited to such class taps and predictive taps.
In addition, in the above description, the structure of
class taps is the same as the structure of predictive
taps. Alternatively, the structure of class taps may
25   be different from the structure of predictive taps.

In the above-described embodiment, a
conversion from an SD picture into an HD picture was

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exemplified. However, the present invention is not limited to such a conversion. Instead, the present invention can be applied to a conversion for a variety of resolutions. In addition, the present invention is

5　　　not limited to the above-described class categorizing adaptive process and high density storage.

　　　　　The other embodiment of the present invention can be accomplished by software as well as hardware. Next, a software process that accomplishes the other

10　　　embodiment of the present invention will be described. Fig. 27 is a flow chart showing a resolution converting process according to an embodiment of the present invention. At steps S111 and S112, a resolution converting process using a class categorizing adaptive

15　　　process and a resolution converting process using a high density storage process are performed in parallel. Outputs of the individual processes are processed by an output determining process (at step S113). Corresponding to the determined result at step S113, at

20　　　step S114, one of the outputs is selected. As a result, the process for one pixel is completed.

　　　　　Fig. 28 is a flow chart showing the resolution converting process using the high density storage process at step S112. First of all, at step

25　　　S121, an input picture of an initial frame is linearly interpolated so as to form a picture having pixels of a HD picture. The picture that has been interpolated is

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stored in a frame memory (at step S122). At step S123,
likewise, an input picture of the next frame is
linearly interpolated. At step S124, using the
pictures of the two frames that have been linearly
interpolated, a moving vector is detected.

At step S125, the input SD picture is phase-
shifted corresponding to the detected moving vector.
The picture storage process is performed for the
picture that has been phase-shifted (at step S126). At
step S127, the result of the storage process is stored
to the frame memory. Thereafter, the picture is output
from the frame memory (at step S128).

Fig. 29 is a flow chart showing the detail of
the resolution converting process using the class
categorizing adaptive process at step S111. First of
all, at step S131, a first area is extracted. In other
words, class taps are extracted. At step S132, a
feature detecting process is performed for the
extracted class taps. Coefficients corresponding to
the detected feature are read from coefficients that
have been learnt (at step S133). At step S134, a
second area (as predictive taps) is extracted. At step
S135, an estimating calculation is performed using the
coefficients and predictive taps. As a result, an
output of which the resolution has been upconverted (HD
picture) is obtained.

Fig. 30 is a flow chart showing a learning

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process for obtaining coefficients used in the
resolution converting process using the class
categorizing adaptive process. At step S141, a thin-
out process is performed for an HD signal with a high

5   resolution (this signal is referred to as teacher
signal). As a result, a student signal is generated.
At step S142, a first area (as class taps) is extracted
from the student signal. Corresponding to the
extracted class taps, a feature is detected (at step

10   S143). At step S144, a second area (as predictive
taps) is extracted. At step S145, data necessary for
solving a normal equation with a solution of predictive
coefficients is calculated using the teacher picture
signal, data of predictive taps, and detected features.

15   At step S146, it is determined whether or not
the additions of the normal equation has been completed.
When the additions have not been completed, the flow
returns to step S142 (first area extracting process).
When the determined result represents that the process

20   has been completed, at step S147, predictive
coefficients are decided. The obtained predictive
coefficients are stored to the memory. The predictive
coefficients are used for the resolution converting
process.

25   As was described above, according to the
other embodiment of the present invention, since the
result of the high density storage process that can

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handle long information in the chronological direction

and the result of the class categorizing adaptive

process can be selected pixel by pixel, a picture with

high picture quality that less deteriorates can be

5   output.

The present invention is not limited to the

above-described embodiments. In other words, various

modifications and applications are available without

departing from the spirit of the present invention.

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